pole, consequently the anticyclone moves with the same speed as the cyclone families, but more slowly than the particular cyclones which during their existence move from the rear to the front of their family.

PERIODS OF METEOROLOGICAL ELEMENTS DUE TO CYCLONE FAMILIES AND MOVING ANTICYCLONES.

Disregarding the obstructions caused by the large continents, cyclone families and moving anticyclones may be imagined to travel continually around the pole.

This movement will produce a periodicity in the meteorological elements throughout the Temperate Zone. Places far north will, for instance, only receive precipitation from the first passing members and places far south only from the last passing members of a cyclone family. Places situated centrally in the cyclone belt, so that they receive precipitation from all the cyclones passing, will have a short spell of fair weather during the passage of the anticyclone which separates successive cyclone families. If the cyclone families perform perfect circuits around the pole,[11] the length of the periods should be equal in all parts of the cyclone belt. They may, however, be of different length in the two hemispheres, as the cyclone families north and south of the Tropics form two independent systems.

A count of the cyclone families passing over Europe in 1921 gives 66 as the total number. This would give a mean duration of 5.5 days, but the authors recognize an error of about 10 per cent.

Various investigators have found short period fluctuations in the climatic elements; probably the most thorough was that of Defant,[12] who found for a single year, 1909, a period of about 5.7 days in the Northern and 7.2 days in the Southern Hemisphere. The cyclone family period of 1921, 5.5 days, agrees so well with the precipitation period from 1909 Northern Hemisphere of 5.7 days that the two periods are considered as identical within the limits of errors.

DISCUSSION.

ALFRED J. HENRY.

The central idea in the foregoing is that cyclones are formed along lines of discontinuity which separate masses of dense polar air from lighter air of tropical origin. The underlying assumption is that the dense polar air is moving westward immediately adjacent to a current of warm air moving eastward. When for any reason the warm current bulges to the northward intruding into the westward moving polar air, the greater density of the latter will cause it to flow along the ground and to cause the warm air to ascend, thereby producing cloud and rain. The condensation of water vapor and the latent heat thus evolved will augment the ascensional movement thus mechanically originated which, together with the modification of the original motion of the air due to the earth's rotation, will create a cyclone. This, in brief, is the reviewer's understanding of the mode of origin of cyclones as advanced by the authors. The various changes which the cyclone undergoes in its brief course has been outlined in the pages preceding.

In view of the fact that the phenomena of cyclones and anticyclones are at best very imperfectly represented on weather maps by surface conditions it must be assumed that the specifications hereinbefore presented should be considered as applying to the conventional cyclone and anticyclone, or possibly to the average of conventional cyclones and anticyclones as they enter Norway.

Forecasters in the United States will be quick to recognize in the specifications hitherto mentioned many familiar phenomena in connection with the movement of cyclones and anticyclones. There are, however, some points of difference between the experience of the Norwegian forecasters and those of the United States; some of these have been mentioned in the series of footnotes appended to this article; others are not easily disposed of within the limits of a footnote. In what follows I shall refer to the most obvious differences between the larger features of the Bjerknes scheme as contrasted with the experience of forecasters in the United States.

Latitudinal differences.—Undoubtedly the origin and development of cyclones and anticyclones are more clearly defined in the latitude of Norway (north 58° to 77°) than in the United States. For the most part cyclones and anticyclones which traverse the latter arrive on its frontiers as fully developed systems of wind circulation. Secondary cyclones, however, frequently develop over the southern and middle portions of the Plateau region in barometric troughs which pass across those regions (from west to east). The development of a primary cyclone, using that term as synonymous with the A-cyclone of the Bjerknes terminology, in the United States is a very rare occurrence.

Cyclone families—The ability to foresee the occurrence of cyclones in families as contemplated in the Bjerknes scheme would be of very great significance in extending the forecasts beyond the conventional period. For reasons indicated in the preceding paragraph it is not only difficult to identify the *A* cyclone of each family on the charts of the United States Weather Bureau, but also, it seems highly improbable from the past experience of forecasters in this country that the occurrence of cyclones in families takes place in the latitudes of the United States with sufficient regularity to make the precept of definite value in long-range forecasting; [13] moreover cyclones at times move southeastward from the Pacific to the Gulf of Mexico and thence northeastward to the St. Lawrence Valley, or develop over the Gulf of Mexico and move similarly, apparently without regard to the development and movement of cyclones along the northern circuit. These cyclones sometimes occur in groups and apparently have no relation to those of the northern groups.

Precipitation.—The area of precipitation in the advance of cyclones in the United States is rarely symmetrically distributed around the front of the cyclone, but is irregularly distributed according to geographic position of the cyclone and the season.

On the Pacific coast and in the Plateau and Rocky Mountain region precipitation occurs as a rule in the rear of the cyclone center instead of the front. On the immediate coast the winds of winter, as is well known are relatively warm as compared with those of the land, and the precipitation that is associated with the movement of the cyclone is of the orographic rather than the cyclonic type. In the Bjerknes type of cyclone the cold air to the eastward of the cyclone is made to curve around the north side of the cyclone and swing in toward the center as a northwest wind. While this movement probably takes place in the conventional cyclone after

[11] The evidence of the Signal Service international series of observations seems to point to a gap in the path of cyclones around the pole as for example over northern Siberia.

[12] A. Defant: Die Veränderungen der allgemeinen Zirkulation der Atmosphäre in den gemässigten Breiten der Erde. *Wiener Sitzber*, 1912, p. 379.

[13] See footnote No. 8 on p. 470.